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Notes On Hawaiian Sand Beach Management

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NOTES ON HAWAIIAN SAND BEACH MANAGEMENT

by

Doak C. Cox

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COASTAL SERVICES CENTER
2234 SOUTH HOBSON AVENUE
CHARLESTON, SC 29405-2413

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THE AUTHOR: Doak C. Cox is Professor of Geology and Director of the Environmental Center at the University of Hawaii. He received his B.S. from the University of Hawaii, and his M.A. and Ph.D. in Geology from Harvard.

Professor Cox is a frequent participant in State and County governmental committees dealing with such diverse issues as water quality, natural hazards, and resource management. He is the author of numerous technical articles and reports covering environmental topics such as tsunamis, impact statements and analyses, and coastal zone management.

He is married and has five children.

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NOTES ON HAWAIIAN SAND BEACH MANAGEMENT

Introduction

General problems addressed

Some of the most serious problems involved in the management of the coastal zone in Hawaii concern the management of the sand beaches of the state. The problems have several roots, including the following:

1. Sand drawn from a beach is a very useful material, particularly in the manufacture of concrete. Sand is also extremely useful when left on and constituting a beach, particularly for recreation. The two uses are incompatible.

2. A beach that may be very useful for recreation may also have detrimental effects, for example if it blocks the mouth of a stream causing flood problems inland. Preservation and removal of the beach are, of course, mutually incompatible.

3. The values of beach use (and of use of the sand of which it is composed) may accrue to particular individuals or to people in common. Some of the sharpest conflicts between individual and communal advantage relate to beaches.

4. Patterns of land-use conventional in our society assume a degree of terrain stability that is particularly inapplicable to beaches.

These notes concentrate especially on the problems associated with the instability of beaches and the interrelation of this instability and the conflict of individual versus communal rights of use. They do not include, except incidentally, more general remarks on coastal zone management problems.

Limitations of these notes

Primarily because I have long been concerned with beach management, I have attempted to pull together in these notes some thoughts pertinent to the interrelated problems as a contribution to the coastal zone management program.

In their possible use, the reader should bear in mind certain critical limitations:

1. These notes are based primarily on personal experience. I have been involved in a few limited beach research projects in the past; and I have drawn on the experience of those. Much more, however, I have drawn on simple and general observations whose lack of depth is somewhat compensated by the length of the period to which they pertain.

2. I have also drawn on pertinent commentary by others, including University colleagues but also notably, with respect to shoreline land boundaries:

- a. Victor Houston (now deceased), an old-time Hawaiian land surveyor and engineer, and one time Delegate to Congress, who addressed the Engineering Association of Hawaii nearly 30 years ago on the topic;
- b. Joel Cox, my father (now deceased), also a Hawaiian land surveyor and engineer who was always much interested in shoreline problems;
- c. Kazutaka Saiki, the present State Land Surveyor.

Except as indicated below, however, I have not checked the information they provided, or my memory of that information.

3. My undertaking of responsibility for coordinating an Environmental Center review of a bill introduced in the 1976 legislative session to define shoreline boundaries of private property in the state, and also Center suggestions on possible amendments to that bill, has led me to a better understanding of the legal principles and precedents applicable to shoreline boundaries. This experience, however, does not qualify me as a legal expert in such matters.

4. Simply through the accident of long acquaintance and concern, I may possibly have identified some concepts or twists of concepts that would not have occurred to experts on beaches and shoreline boundaries. However, my discussion of natural beach processes is not intended to take the place of the detailed and authoritative discussions provided to the coastal zone management program.

5. Although my principal reason for setting down these notes is to pull together scientific, legal, engineering, and economic concepts related to beach management, I recognize that others are giving much more attention to this pulling together than I can afford.

6. A draft of the notes has been reviewed by Ralph Moberly of the Department of Geology and Geophysics and J. Frisbee Campbell of the Hawaii Institute of Geophysics. Although I have made some changes on the basis of their comments, they cannot be held responsible for my conclusions.

Because of these limitations nothing in these notes should be taken at face value. They may, however, provide some stimulus to others, and I shall be pleased if they are found of use in this way.

Beach Processes

Quasi-equilibrium conditions

Over very short time intervals, or as averaged over a year, a beach may appear more or less stable. Any child playing on a beach learns quickly that either a mound or a hole that he makes in the sand will become quickly obliterated if it is within the reach of the waves. A beach may vary considerably from season to season, yet return to approximately the same shape and position year after year. The apparent stability is the result of a dynamic equilibrium between forces tending to move sand to and away from any portion on the beach, and on a broader scale between the rates of sand production and the rates of loss of sand.

Most beach sand of Hawaii consists of shells and fragments of shells, coral, and other calcareous material. Non-calcareous detrital material resulting from marine shoreline erosion, or erosion inland with stream delivery, may locally be important. Sand may be lost from a beach by inland transport by winds or by waves of uncommon height such as tsunamis, by long-shore transport, by transport to deep water, by attrition, or by lithification to form beachrock or aeolianite or as a component of reefrock. Seasonal changes in beach-front position represent shifts of sand between the beach and shallow-water deposits. Pocket beaches, isolated above water, may be dynamically interconnected through long-shore transport in shallow water. The various parts of an interconnected system of sand production, temporary storage, and loss constitute a littoral cell.

Natural non-equilibrium conditions

In spite of the seeming stability of beaches over very short-term intervals, and the tendency of some beaches to return annually to the same position, there are no terrain features that are more significantly unstable than beaches, at least in Hawaii. With close observation, most can be seen to change slightly with each wave. They are commonly changed substantially by the waves of a single local storm or even a very distant storm. Most show significant seasonal changes. These changes over periods of a year or less represent shifts of sand from one part of a beach face to another or between the beach and shallow water deposits.

Most Hawaiian beaches show longer term changes also--some reversing and some apparently not reversing. Over the last several decades

some have shown a net extension seaward; some have shifted in azimuth, growing at one end and retreating at the other; and some have shown a net retreat landward. According to Ralph Moberly (personal communication), about a third of the Hawaiian beaches showed significant net retreat during the 1963-72 decade of observation by the Hawaii Institute of Geophysics, about a third showed significant net extension, and about a third showed neither net retreat nor net extension.

The long-term changes may reflect just longer term variations of wave energy or direction of prevailing wave approach to shore of the same sorts that cause the seasonal changes. The long-term retreats may, however, reflect irreversible reductions in the rate of sand production or increases in exposure resulting for example from erosion of protecting reefs. Some may result from recent changes in coastal level, some the lagging effects of the last change in sea level about 2,000 years ago.

Artificial non-equilibrium conditions

Artificial removal of sand may also result in non-equilibrium--far more extensively than seems ordinarily to be realized. Because of the tendency toward short-term equilibrium the removal of sand from some point on a beach face is rapidly compensated by shifts of sand from other parts of the beach, from the shallow water deposits, or from other beaches in the littoral cell. Because the effects of the removal may be so widely distributed, the removal may be continued for some time before they are detected. Since the removal can rarely, if ever, have a significant effect on the rate of sand production, it can fail to have an effect on the overall volume of sand in a littoral system only if it results in a decrease in the rate of sand loss from the system. A decrease in the rate of loss to deep water can result if the volume of sand in temporary storage in shallow water is reduced, and such a reduction is likely to be coupled with retreat of the beaches.

It is difficult, however, to distinguish between natural and artificial causes of beach retreat except where there have been no artificial removal of sand of sufficient magnitude to account for the retreat. Beach prograding (seaward movement of the beach face) may be induced locally by construction of groins, breakwaters, etc. Ordinarily such local prograding is balanced, however, by beach retreat elsewhere.

As artificial removal of sand is likely to result in beach retreat, artificial replenishment of sand may result in beach prograding or in the reduction of beach retreat.

Beach retreat may be induced locally also by the construction of seawalls, groins, and other structures. Sea walls may protect structures inland from waves but reflect wave energy in such a way as to promote the removal of sand seaward from the seawall. Groins may result in sand accumulation along the beach in the direction from which the sand is

being naturally transported but in sand removal along the beach in the opposite direction.

Artificial sand removal

Purposes

As noted previously, Hawaiian beach sand is useful for purposes other than as material of which beaches are composed. It has been used as ordinary fill material and as road surfacing material. Small amounts of sand, especially of the more uncommon sorts are collected and sold as souvenirs. Some of the common calcareous sand has been used as a soil additive, buffering against low pH. Considerable amounts have been used on Maui for the manufacture of lime. The most valuable use is as the fine aggregate in the manufacture of concrete. This use, the artificial replenishment of other beaches, and the clearing of stream mouths are now probably the only significant uses for sand removal from Hawaiian beaches.

Effects of Removal

As indicated in the section on beach processes, the removal of sand from a beach affects most of the littoral cell system. Indeed the removal of sand from any part of a littoral cell may affect the beach. However, the removal of sand in a littoral cell with unidirectional long-shore transport is unlikely to affect beaches or other parts of the cell very far upcurrent from the point of removal. Removal beyond the depth to which waves can move sand back to the shoreline cannot affect the beaches. Removal from inland areas beyond the reach of waves will also ordinarily not affect the beaches.

The distances to which the effects of large volumes of sand removal can be significant may be large. The effects of sand removal for lime manufacture at Paia, Maui, near the upcurrent end of a long littoral cell, may well have contributed significantly to the retreat of the beaches in the system westward to Kahului. The effects of the removal for construction purposes at Waimea, Oahu, may possibly have contributed significantly to the retreat of beaches southward to and including Haleiwa Beach.

Resource renewability and non-renewability

Beach sand resources share both renewable and non-renewable characteristics. Sand is being produced, transported, and lost continuously, and a rate of removal that is a small fraction of the rate of transport past the point of removal may have little effect. The removal process in this case is essentially a harvest. The tendency of the

littoral cell system to maintain dynamic equilibrium commonly results, indeed, in shifts in the patterns of transport to transfer, to a point of sand removal, more sand than would naturally be moved.

The volumes of sand in storage are, however, so large in most littoral cells compared with the average rates of transport, that rates of sand removal considerably in excess of the total transport through the system may be sustained for long periods of time. The major storage is likely to be on the shallow bottom. Because the sand is spread out over a very large area, the rate of change of sand depth may be very small even with a major withdrawal rate, and the change is in any case difficult to observe because it is under water. The exhaustion of a shallow bottom sand reservoir will, however, affect the beaches adjacent and downcurrent, and the effects, concentrated on the smaller area of the beaches, will be much more apparent.

Determining whether a sand-removing operation is essentially harvesting or mining the sand is not easy. I am unaware of any sound determination whether the major present removal operation, that at the west end of Molokai, is essentially harvesting or mining sand. Fortunately, as pointed out by Moberly, Campbell, and Coulbourn (Sea Grant Tech. Rept. UNIH-SEAGRANT-TR-5-03, May 1975) the removal site of Papohaku beach is near the end of the littoral cell transport system. Hence sand removal is less likely to be deleterious at this site than elsewhere.

Effects of sand removal at depth offshore

As indicated above, beaches are unlikely to be affected by sand removal beyond depths from which waves can move sand inland. Effects could be felt only if the deposits mined are very deep, and the mining resulted in an increase in seaward slope and hence an increase in seaward transport from the shallow-water zone. Indeed harvest at moderate depth from the stream of sand moving irreversibly to deep water would have no effects on the beaches.

The shoreline setback law provides both a depth limit and a shoreline distance limit to sand removals. Because distance has little importance, the law as it is now written is probably unduly restrictive. The limiting depth to which waves may move sand shoreward varies, of course, from place to place, but it should not be difficult to determine at any place a conservative limit applicable to sand removal.

Effects of sand removal inland

It seems to be assumed that sand removal inland from an active beach will have no effect on the beach. If, however, the excavation is

within the reach of waves of uncommon magnitude, such as tsunami waves, it is likely eventually to be filled with sand washed inland from the active beach. The effects of the removal are, thus, except for their deferral in time, the same as those of removal from the beach itself.

On a beach that is subject to progressive retreat, an excavation may become within the reach of even ordinary storm waves. In that case, even if the excavation has earlier been filled with soil, the soil will be exposed to erosion, and thus become a source of beach contamination and water turbidity.

Effects of sand removal from stream mouths

As indicated above, sand may be removed from a beach not only for its uses but to clear the mouths of streams, thereby reducing the flood hazard inland. Need for such clearance has been increased by the diversion of low water flow from many streams. If the sand removed from the stream mouths is returned to the littoral cell, the effects on the beaches except at the stream mouths themselves are minimal.

Land use on beach coasts

Uses of beaches and adjacent lands

That beaches and adjacent lands have considerable use is clear from their market value. There are various kinds of use, some of value primarily to individuals, some primarily to particular groups of people, and some primarily to people in common.

Distinction is usefully made between the active parts of beaches, surfaced with bare sand, and lands adjacent to the active beaches. Except for implications as to stability it makes little difference whether the lands adjacent are underlain by beach sand, and hence are geomorphologically part of the backbeach, or whether they are underlain by non-beach material. In this section beaches will refer to the active bare-sand parts of beaches only. Lands adjacent to beaches can, of course, be used for a number of purposes that have no special relation to beach proximity. Because of the special value attached to beach proximity there is little societal gain from the allocation of beach fronted lands to non-beach-related ones. Some of the uses of land particularly taking advantage of beach frontage are tabulated below with attributions of their principal value:

<u>Use</u>	<u>Principal value attribution</u>
Housing	Housing occupants and owners
Private back-beach recreation, beach facilities and beach access	Owners and guests
Resorts	Visitors and owners
Public back-beach recreation, beach facilities and beach access	Public
Other beach-related services	Public and owners
Waste processing for ocean disposal, facilities related to submarine cables	Owners and public
Esthetics	Individuals, visitors, and public

Beach-fronted land usage for housing resorts, beach facilities, beach-related commercial facilities, and waste disposal require the construction of buildings of various sorts.

Uses of the beaches themselves are as follows:

- Sunbathing
- Swimming
- Body surfing
- Fishing
- Access to water for boating and board surfing
- Access along shore
- Waste transport to ocean
- Communications cable crossing
- Esthetics

Most of the uses of the beaches are potentially of value to people in common, even though they may in actuality be of value primarily to individuals or small groups because of limitations of access.

Waste transport to the ocean and communication cables require construction on the beach, but the pipes and cables are ordinarily laid below the beach surface. Access to the water for boating may involve construction of launching ramps or piers.

Use incompatibilities in general

A number of incompatibilities among these uses will be apparent, especially incompatibilities between restrictions of use to individuals and particular groups and openness to use by people in common, reflected, in general by private versus public ownership. Of principal concern in these notes, are incompatibilities of concepts of ownership, use, and consequences of use with the dynamic character of beach processes, with particular regard to the non-equilibrium dynamic characteristics.

Some of these incompatibilities are related to the concepts of land identification, land ownership and rights of use, and boundaries. Others are related to the structures involved in land use.

General concepts of land identification

Among the many characteristics of land that are important to its human use, two that are fundamental to the description of land with respect to its ownership and use are its area and its location. At least in the English language, references to these two are easily confused. Area may refer to the magnitude of horizontal extent of land, but "an area" often refers to a piece of land in a certain location. Area will be used here in the first sense only. In detail, the location of a piece of land is determined by the locations of its boundaries.

Problems arise from the concepts that both the area and location of a piece of land are fixed. The concepts of fixity of boundaries is most important in relation to the evaluation of land for purposes of taxation. As will be seen, both concepts are significantly invalid when applied to lands bordered by beaches.

Concepts of land ownership

In Hawaii before the Mahele, land-use concepts were essentially feudal. The land was held by the alii, subject to the Moi, and managed by the Konohiki. Although by custom, house lots were regarded much as private property, the produce of some lands and waters was specially designated for the alii, and some lands were subject to special kapus, most land was held for use for the people in common.

With the Mahele, most land was transferred to private ownership. In the original concept, private ownership implied the right of the owner of land to almost exclusive determination of its use.

In one respect, the actual exercise of the right was long deferred. When land values were lower than they are now, when the liability of land-

owners for accidents to trespassers was at least in practice less distinct than now, when most of those who could be considered trespassers on a major landholding were either tenants or employees of the landholder, and when the legal implications of permitting trespass were not as clear as now, most major landowners paid little attention to trespassing. Increasingly in the last several decades, however, the common use of such private land for access has been disallowed by the owners. In this process, the public access to beaches, once tolerated by the owners of the access routes, has become severely restricted. It may be questioned whether the principle of eminent domain could not have been used more extensively in the past by the territorial and state government, in order to establish public ownership and hence clear public rights to the use of access routes formerly subject to de facto communal use. By now, however, private ownership of most of the routes has probably been reasserted by the public exclusions, and the establishment of public rights of use would be regarded as a "taking" for which the land owners would have to be compensated.

Concepts of use determination on private lands

During the same period while the effects of the concept of exclusive determination of rights of use of land by its owners have been increasing with respect to access, the concept itself has been changing with respect to other use rights.

Significant restrictions on private land use go back at least seven decades to the time when forest reserves were established, but have been greatly extended by the use classification of all lands by the State and by zoning within urban districts by the counties. Restrictions particularly pertinent to the coastal zone were imposed in 1973 by the Shoreline Setback Law, in 1975 by the interim Shoreline Protection Act, and most recently in 1977 by the Coastal Zone Management Act. As with other existing land use districting and zoning controls, these measures do not prescribe how a private land owner must use his land, or what structures he must put on it. Rather, they provide controls for how a landowner may not use his land, and what structures he may not put on it. An owner of agricultural land, for example, need not grow crops on his land. He may leave it fallow, but he cannot fill it with houses.

Public pressures on the use of private land are also effected through taxation policies. Combined with the use restriction, tax policies may force a landowner to use his land in accordance with the use designation, because he needs the income from the land used as extensively as permitted to pay the taxes on it. Indeed tax policies may subvert the land use policies, as when the "highest and best use" of land, which is the basis for tax assessment, is interpreted, not as the use that has been determined as best through districting or zoning, but as the use resulting in the highest market value for adjacent land.

Significance of boundaries

In modern concepts, then, boundaries are of importance, not only as divisions between lands belonging to different private owners and between private and public lands, but between lands on which various uses are permitted and others on which the same uses are prohibited, regardless of ownership.

The boundaries of small individual parcels of land in Hawaii, are, in general, arbitrary. Major land boundaries, however, have a marked basis in physical geography. Those related to shorelines are particularly pertinent to beach management problems.

Shoreline and shoreline-dependent boundaries

Shoreline boundaries had little significance to coastal land usage in the pre-Mahele period except where there were special kapus, for example for some fish ponds. With the introduction of private land concepts by the Mahele, bounds for the private land had to be established. In many cases the boundaries were vague. Even the general locations of some "floating kuleanas" have still not been established. Boundary descriptions with reference "to the shoreline" and "along the sea" seemed adequately specific when land values and pressures for land use were low. Some areas transferred to private ownership were not limited to terrestrial lands bounded makai by the shoreline but extended onto reefs or into bays in which the fishing rights were established as privately owned. The confusion as to the locations and boundaries of lands to which private ownership had been applied led to the requirement of surveys by registered Hawaiian land surveyors and to the establishment of the Hawaiian Government Survey (continued now as the Survey Division of the Department of Accounting and General Services).

The seaward boundaries of private lands were described in many cases as "ma ke kai" or as following the "kahakai". "Ma ke kai" means, simply at or along the sea. "Kahakai" is now defined as the shoreline or the coast, but etymologically means the "mark of the sea." In the opinion of Victor Houston, a Hawaiian land surveyor and onetime delegate to Congress, the rationale for the choice of the term considerably narrows its possible range of its meaning in the context of a land boundary. If a canoe was drawn up on the beach beyond the reach of the highest waves it should be safe also from molestation by passers-by on the beach. Hence the appropriate limit to common beach usage on one side was the uppermost reach of the waves, and this should be also the limit of private ownership on the other side.

Wave runup on beaches is of course variable. Recent wave runup is indicated by swash marks on the beach, wave runup farther back in time by

debris lines, and the highest annual runup by older debris lines and vegetation lines. The "mark of the sea" most appropriate for a land-title boundary would be the line more or less well defined by the seaward limit of perennial land vegetation or the uppermost debris line. The kahakai thus determined is in general nearly coincident with the crest of the winter beach berm.

Later, with the more sophisticated recognition of the statistical parameters of tidal motion, averaging out the effect of waves, some seaward boundaries were established in terms of the lines of mean high water, and possibly the lines of mean sea level, mean low water, and mean lower low water.

The similarity of the term "mark of the sea" to high water mark, and the similarity of high water mark, in turn, to the line of mean high water or high tide, led for a few decades prior to 1968 to the mistaken identification of the terms "kahakai," the description "ma ke kai," and the term mean high water mark with the line of mean high tide.

However, recent decisions of the State Supreme Court return to the original concept. In Application of Ashord (50 Haw. 314, 440Pzd 76, 1968) the Court decided that:

"ma ke kai" is along the upper reaches of the wash of the waves, usually evidenced by the edge of vegetation or by the line of debris left by the wash of the waves.

In County of Hawaii v. Sotomura, (55 Haw. 176, 1973) the court found that the high water mark had been determined by the "limu" or seaweed line (actually the line of seaweed debris) but ruled that:

We hold as a matter of law that where the wash of the waves is marked by both a debris line and a vegetation line lying farther mauka; the presumption is that the upper reaches of the wash of the waves over the course of a year lies along the line marking the edge of vegetation growth. The upper reaches of the wash of the waves at high tide during one season of the year may be further mauka than the upper reaches of the wash of the waves at high tide during the other seasons. Thus while the debris line may change from day to day or from season to season, the vegetation line is a more permanent monument, its growth limited by the year's highest wash of waves.

For greater precision consistent with the Supreme Court rulings the kahakai might be defined as:

The line of greatest annual average wave reach, as this may be marked by debris lines left by waves reaching highest with mean annual frequency, or by the seaward edge of perennial land vegetation excluding especially salt-tolerant species.

Although the Supreme Court rulings indicate that ambiguously described shoreline boundaries of private property are to be interpreted in accordance with the original Hawaiian kahakai concept, there may be some legally valid, unambiguous shoreline boundaries that are inconsistent with the kahakai.

If the matter of shoreline boundaries to private land ownership is complex, the complexities are increased with respect to boundaries pertaining to differential rights of use of land, both public and private.

Two boundaries with respect to use rights are defined in such a way that they seem dependent on the kahakai, determined as discussed above. One is the shoreline setback line established by each county pursuant to the Shoreline Setback Law (Hawaii Rev. Statutes Chap. 205, Part II). The language of the law is confused, but its intent is that the shoreline setback line shall be 20 to 40 feet inland of the kahakai. By the law, special controls on construction, maintenance of structures, and removal of sand were granted to the counties in the area between the kahakai shoreline and the setback line. By mistake the law was amended in 1974 eliminating the powers to control structures and structure maintenance. A further amendment to restore these powers was passed by the House of Representatives of the 1975 Legislature but died in the Senate. The powers were not restored by following sessions of the Legislature.

The Shoreline Protection Act of 1975 (Act 176) provided the counties with powers somewhat similar to those of the shoreline setback law but over a broader area, extending in general 100 yards inland from the kahakai. The Coastal Zone Management Act of 1977 (Act 188), which replaced the Shoreline Protection Act of 1975, made permanent these interim powers, and required the counties to amend their special management area boundaries established by the Shoreline Protection Act so as to meet the objectives and policies of the new Coastal Zone Management Act.

Implications of sea-level change and beach instability on boundaries

However defined, the use of a shoreline as a boundary with respect to ownership or permitted uses of land implies a stability that does not exist for any marine shoreline and is particularly invalid in the case of a beach shoreline.

Part of the problem relates to the instability of sea level. Sea level changes with the world-wide hydrologic balance, the temperature of the upper part of the ocean water column, the astronomic tide, and wind and atmospheric pressure. Relative to any coast, sea level may also change with tectonic change in coastal level.

Mean sea level and tide levels such as mean high water and mean lower low water have been determined on various Hawaiian coasts by tide gauging of durations from a few days to many decades. Averages for periods of more than a few days but less than a year may differ from long-term averages by more than a half a foot. However, estimates of long-term averages may be made at short-term gauging stations by comparison with the records of long-term gauging stations. On most Hawaiian coasts sea levels may also be determined on an ungauged coast by leveling from a gauge station. However, at least second-order leveling is needed to assure accuracy with a few tenths of a foot if the level lines are several tens of miles in length.

Even long-term mean sea level may change with tectonic change. On most Hawaiian coasts, there is no firm evidence of long-term changes greater than about .01 ft/yr. for the last approximately 2000 years, when effects of the last glacial period stabilized. Locally, however, on the island of Hawaii, there have been historic changes in coastal level of several feet. The Hawaii earthquake of November 1975 was accompanied by such changes on the South Puna and Kau coasts.

Mean high water level and mean lower low water level are approximately horizontal surfaces, and horizontality is determined by mean sea level. Land boundaries are however lines, and have vertical rather than horizontal implications as to extension. Sea-level shorelines represent the intersection of one of the defined sea-level surfaces with the coast. Not only vertical changes in coastal level but horizontal coastal prograding or erosion affect the positions of these intersections. At a beach, any sea-level shoreline is likely to shift significantly with seasonal changes in beach front position, and on some Hawaiian beaches the seasonal shifts may be on the order of 100 feet.

Of the various possible shoreline land boundaries, that least subject to change in position on a beach is the kahakai as defined previously. Lower debris lines may be formed and removed many times annually, temporary berms may be formed, and temporary growth may extend the vegetation line seaward.

All shorelines, including even the kahakai shift in position on a beach that is subject to longer term instability, whether the instability is due to natural causes or induced by human activities. Allowance for variation in shoreline position as must exist on an unstable beach is provided through the concepts of erosion and accretion. As developed with respect to land ownership adjacent to streams, erosion in legal usage refers, not to the removal of individual particles from the bank of a stream, but to the retreat of the streambank itself, and accretion to the generally corresponding prograding of the opposite bank. Since the stream itself is

the effective physical boundary, the legal concept is that, if by natural processes the stream changes position, the owner of one bank loses land and the owner of the land on the opposite gains land. These concepts of erosion and accretion have been extended to changes in beach shoreline position. The concept of accretion has logically been so extended by the State Supreme Court even to changes in shoreline position on a normally stable shore that has been extended by a lava flow, and both erosion and accretion concepts would logically be extended to shorelines changed in position as a result of coastal submergence or emergence.

However defined, the use of a shoreline as the seaward boundary of private lands, is incompatible with the further definition of private lands as having constant total areas. However, the problem with changes in area with respect to land values assessed for taxation could be coped with by land resurvey at appropriate intervals.

Implications of beach instability on structures

As indicated in an earlier section, such structures as sea walls, groins, and breakwaters have influences on beach stability. Beach instability also has clear implications as to structures, even structures built on and intended to remain on land.

The greatest problem lies in beach retreat. At many beaches in Hawaii, permanent structures, including houses, and hotels on private land, and beach pavilions and boat launching ramps on public land have been built in what were back-beach areas, disregarding the potentiality for beach retreat that has subsequently materialized. Through the retreat, the structures have been exposed to undermining or wave attack. In some cases the problem has arisen simply from natural long-term progressive retreat. In other cases, the long-term retreat has probably resulted from sand removal, not necessarily in the immediate vicinity of the threatened structures. In still other cases, the retreat may have been part of what would have been a natural long-term reversing shift of the beach front, but the measures taken to protect the structures, mainly the construction of sea walls, have effectively prevented the reaccumulation of sand and the eventual prograding of the beach. One of the major implications of beach retreat on structures is, thus, indirectly, the aggravation of beach retreat through attempts to save the structures.

Beach prograding may also result in problems, though not so often as beach retreat. Structures intended to be on the shoreline, may be left inland. Boat launching ramps may be covered with sand and small boat basins or their entrances may become filled with sand as a result of beach prograding.

Public management of beaches and beach-fronted lands

General purposes

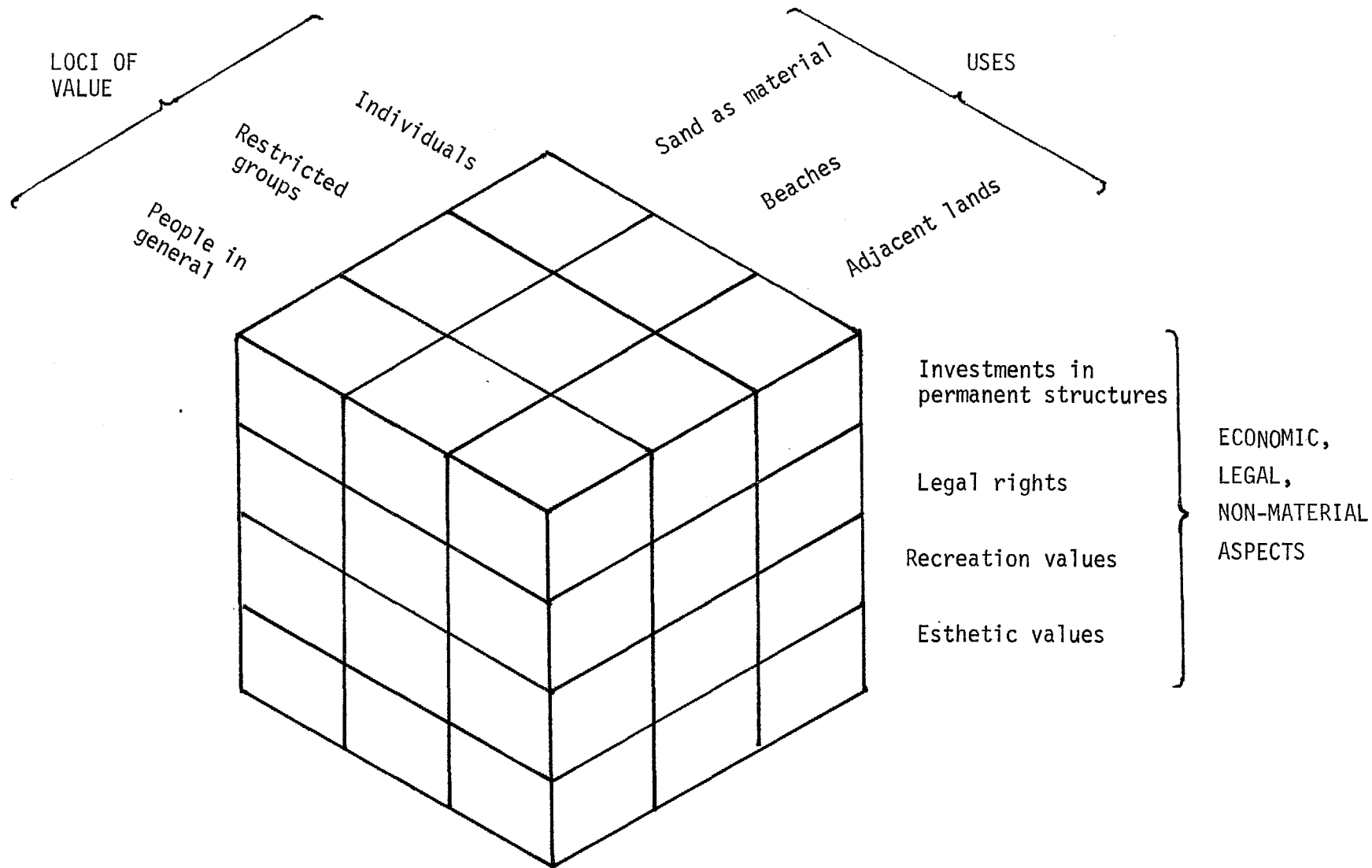
The purposes of management of beaches and beach-fronted lands are, of course, to minimize the beach-associated problems discussed earlier as well as problems associated with the coastal zone more generally and with still broader problems. The governmental role in such management relates especially to the safeguard of the common public interests in the beaches and beach-fronted lands, as distinct from the private interests. More specifically the functions of a sound governmental management program are to assure, as well as possible, the maximum long-term human benefits from the beaches and adjacent lands.

There is, of course, no assurance that, as it applies to private lands, a governmental management program will actually be more representative of common long-term needs than private management programs. Both good and bad examples of governmental management as well as private management may be pointed out. Governments do, however, have the clearest responsibility for looking after the common interests in general, and only governments have management responsibilities on public lands.

Values to be considered

The values to be considered in a beach management program may be considered as those presented in a three-dimensional matrix:

<u>Dimensions</u>	<u>Subdivisions</u>
1. Uses to which values attach	a. Beach sand as a material b. Beaches c. Adjacent lands
2. Economic, legal and nonmaterial aspects	a. Investments (including those in permanent structures) b. Legal rights c. Recreational values d. Esthetic values
3. Locus of value accrual	a. Individual b. Restricted groups c. People in general



Problems and their resolution in general

The problems faced in a management program include the usual conflicts among potential but incompatible uses, but in the cases of beaches and adjacent land are complicated by the instability of the beaches.

It is clear that the severity of the management problems varies with the degree of instability and with the direction of progressive changes of the beaches. It is also clear that the severity varies with the extent of development on and immediately back of the beaches. In both cases, the differences in potential severity suggest differential levels of governmental regulation. In both cases, therefore, general guidance as to the differences should be provided in law, and some agency or combination of agencies should be mandated by law to make the distinctions and establish the detailed regulations.

Although the State's Coastal Zone Management Program does not provide for detailed provisions appropriate to the particular problems associated with beaches and adjacent lands, two new planning elements pertaining to shorefront access and protection and mitigation of shoreline erosion may lead to significant improvements in beach management. In addition, the State Department of Planning and Economic Development is mandated to prepare guidelines for the 1979 session of the Legislature that may help to further clarify beach management policy. A discussion of guidelines thus seems appropriate. Some are tentatively set forth in the following sections.

Determination of long-term beach trends

It is clearly critical to estimate as well as possible whether, in the future, a particular beach is likely to prograde, to retreat, or alternately to prograde and retreat, and to estimate the ranges of oscillation in position and average rates of retreat or prograding. At present, the best guidance to the future trend is the historical record. Little historical study has been made of most beaches, and even careful study in many cases may have been significantly influenced by artificial sand removals, whose effects may or may not have ended.

Ideally, the best practicable estimation as to beach trends should have been made before the coastal zone plan was approved. However, what is best practicable in the long run was not possible in the short time in which the plan was prepared. Hence, as part of the ongoing coastal zone management program, emphasis should be placed on a combination of historical review, monitoring and analysis of beach instability, and, as justified by the results of the analyses, modification of existing regulations provided for in the Coastal Zone Management and other laws. Initial regulations, such as those that might be established through guidelines, should be based on the assumption that retreat is probable, at least for extended periods, unless there is clear evidence to the contrary.

Extent of present private ownership

A clear determination should be made, if possible, of the present seaward limits of private ownership of land adjacent to beaches. The possibility is here recognized that, in spite of the recent Supreme Court decision, private ownership may, by the original grant descriptions, extend to sea-level lines makai of the kahakai at some beaches.

It should be recognized that:

1) the present seaward limits of private lands, if defined either by the kahakai or sea-level lines, are subject to natural erosion and accretion.

2) Values attaching to public uses of beaches and adjacent lands may justify public acquisition of what are now private lands (see sections on access).

3) Common interests may also justify governmental regulation of uses on private lands (see sections on sand removal, new construction, and existing structures).

4) The boundaries to which public ownership and various kinds of public regulation should extend should be set in recognition of the beach instability problem.

Public access along the shore

In general, the value of public access along the shore justifies public ownership of the beach face. Where the boundaries of adjacent private lands are at or inland of the kahakai, public access along the beach presents no problem except during periods of high waves and maximum seasonal beach retreat, when beach use would be minimal. Beach instability in this case also presents no problem, because if the beach changes position the boundary to the private land also changes.

Public ownership of beaches only to sea-level lines seaward of the kahakai may unduly restrict public access. Even at low tide waves may wash considerably higher than the mean-high-tide line, for example. However, if a beach is bounded at both ends of cliff shore-lines and there is no public access to the beach, except by water, the public acquisition of the beach would seem to have very low priority.

It should be recognized that wherever public access along the shore is permitted, a maintenance responsibility rests on public agencies. This responsibility should be pinned down.

Public access to the shore and use of adjacent lands

Public needs for access to beaches and public needs for use of lands immediately adjacent to beaches justify considerably greater public ownership of beach access routes and backbeach areas than at present. Immediate public acquisition of all of the access routes and backbeach areas that should be acquired is neither necessary nor economic. What seems needed is an acquisition program including:

- 1) identification of the acquisitions that seem justified;
- 2) the assignment of priorities for the individual acquisitions based on a combination of immediate needs and the threats of private development that would make acquisition later more costly and less desirable.
- 3) an annual appropriation at a rate that will complete the acquisitions now seeming justified in a reasonable period of time;
- 4) periodic reexamination of acquisition needs.

In acquiring lands adjacent to beaches, the potential for beach retreat must be recognized. If a piece of land extending 100 feet from the shoreline is needed, for example, it would accomplish little to acquire just the 100 feet if the shore were retreating 10 feet per year, especially if the piece was backed by private land subject to development with permanent structures in the next few years.

Again it should be recognized that public ownership of beaches, backbeach areas, and access routes places a maintenance responsibility on public agencies.

The responsibilities for the acquisition program and for maintenance of public beaches and adjacent public lands need to be clearly defined.

Regulation of sand removal

The uses of sand in place on beaches are so great compared with the uses of sand as a material that, in general, no sand removal should be permitted on either public or private land, whether from the beach, from the shallow water part of the littoral cell, or from the backbeach within the reach of the waves even of extreme storms or tsunamis. Sand harvest at rates representing small fractions of sand transport rates may be permissible, but convincing evidence should be presented that the removal will have no significant consequences in causing immediate or future beach retreat anywhere in the littoral system before permission is granted. Sand mining at considerable distance inland from the beach may be permis-

sible even if the removal site is occasionally inundated by waves, providing there is no significant likelihood that the waves will move sand from the active littoral system to the removal site. Again convincing evidence should be presented to justify the permission.

The inland boundaries to which sand removal should be prohibited should be established in recognition that for all beaches, there are likely to be long term changes in beach front position and that retreat is more or less probably in the moderate term or long term for most beaches. The boundary to the present shoreline setback area, whether or not it is appropriate on non-beach shorelines, is clearly not far enough inland to serve as an appropriate boundary for the sand removal prohibition on many sand beaches. Even the 100-yard minimum extent of the special management area in the interim Shoreline Protection Act may not be sufficient for some beaches.

The Coastal Zone Management Act of 1977, which supercedes the Shoreline Protection Act of 1975, calls for an amendment of these boundaries by the counties so as to be consistent with the Act's objectives and policies. The Department of Planning and Economic Development has interpreted this to mean that the minimum boundary should include those areas 150 feet inland of beaches experiencing critical retreat problems. However, it should be noted that the counties have not made serious efforts to amend the special management areas, and hope to change the boundary-amendment requirement in the 1979 Legislature.

The prohibition should not extend to removal of sand from stream mouths, but it should be made clear that the sand so removed must be returned to the littoral cells. A formal sand removal permit system should be required by law for either sand harvest or sand mining, to be instituted in an agency having competence in littoral processes.

The implications of this guideline may well be a significant decrease in the rate at which beach sand can be supplied for construction. Alternatives to beach sand as used in construction exist in sand-sized crushed rock and offshore sand, as indicated previously. An important indirect implication is, therefore, an increase in the cost of sand for construction. The extent of the restrictions on mining and harvest should be determined in recognition of the probable cost increase and the value of sand on beaches. If the cost increase implied by the restriction described is unduly high, the only reasonable alternative is to give up to sand harvesting the long term use of certain beaches, preferably those from which considerable sand harvesting is possible and attached to which small values for beach use are attached.

Regulation of construction

The potentiality for long-term reversible or progressive beach retreat has particular implications regarding the regulation of construction on the beaches and adjacent lands. The historical experience indicates the desirability of such regulation as applied to building on a private land just on the basis of safeguarding the landowner from risks of which he may well be unaware of which the present owner expects to avoid by sale of the land after development. It is even more justified by the threat to common interests in the beach associated with the effects of the protective structures which the owner may construct to save his building from wave attack or undermining when the beach retreats. The justification is by no means restricted to construction on private land.

The needs for regulation of construction extends, of course, to structures on beaches as well as those on adjacent lands. For example, the construction of sea walls or groins is often of concern because of the beach instabilities they cause.

"Permanent" construction should ordinarily not be permitted on land where a structure will be threatened by either reversible or progressive beach retreat, within the useful life of the structure. Non-permanent construction may logically be permitted farther seaward than permanent construction, but it should be recognized that the permission to construct non-permanent structures on land does not imply freedom to construct protective works if the structures should in the future be threatened by beach retreat. Construction should not be permitted on a beach if the structure will tend to result in retreat of the beach, retreat of another beach, or impudence of public access or use of a beach.

However appropriate the setback lines in the Shoreline Setback Law may have been on non-beach shorelines, they are clearly not far enough inland to serve as an appropriate boundary for the prohibition of construction on many sandy beaches. The 100-yard inland boundary of the special management area in the interim Shoreline Protection Act is probably farther inland than is justified for the prohibition of construction on almost all beaches, except on esthetic grounds.

The regulation of construction on beaches and adjacent lands should be placed in the hands of an agency having competence in shoreline processes.

In most cases the regulation of structures is so much in the long-term self-interest of the land holder that it involves no "taking" of rights for which a private owner would have to be compensated. In some cases, however, the granting of tax relief may be justified (see section on conservation designation and tax policy).

Regulation of present structures

The problem of beach retreat relative to structures is considerably more difficult in the case of now-existing structures. The removal of the structures would be costly, and the compensation of their owners much more costly.

Where only a few buildings have been constructed, particularly if they are not now exposed to the waves or undermining, no immediate governmental action seems justified, but the policy should be established that the construction of sea walls to protect such structures will not be permitted if such construction would have deleterious effects on the beach, and the owners should be notified of this policy.

Where buildings have been erected along an entire beach and threatened by beach retreat, however, particularly if sea walls have already been constructed the active beach has already been reduced, the damage may be essentially irremediable or at least not remediable except in the very long term. If there is high potential for public use of the beach, a policy of prohibiting additions or replacement of the building or repair or maintenance of beach-disturbing protective works may be justified on the basis that eventually, when the buildings reach the end of their useful lives, the beach can be restored. Compensation or at least tax relief for private owners may be appropriate in this case. On some beach shorelines, artificial beach maintenance may be justified, but not only the costs of the maintenance operation but the value of the sand used in maintenance must be recognized in determining the justification.

The provision of even general guidelines as to policy with respect to beach shorelines already developed with structures threatened by beach retreat cannot be undertaken until the scope of the problem is determined by survey.

Conservation designation and tax relief

Even where the rights of private ownership are not sufficiently impaired by the regulations respecting sand removal and construction to justify direct compensation, the continued imposition of land taxes based on the full value of beach-front lands may be unjustified. Consideration should be given to:

a) Designation of those lands adjacent to beaches on which the use regulations are most stringent as conservation lands.

b) Interpretation of the "highest and best use" of these lands for tax evaluation purposes as the restricted conservation use, not the use for beach-front housing or commercial purposes.